

CONTRIBUTIONS
FROM THE
CUSHMAN LABORATORY
FOR
FORAMINIFERAL RESEARCH

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These contributions will be issued quarterly. They will contain short papers with plates, describing new forms and other interesting notes on the general research work on the foraminifera being done on the group by the workers in this laboratory. New literature as it comes to hand will be briefly reviewed.

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CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

74. THE TERM "ARENACEOUS FORAMINIFERA" AND ITS MEANING

By JOSEPH A. CUSHMAN

For many years the term "arenaceous foraminifera" has been used, and its meaning has been seemingly unquestioned. Lately discussions have seemed to show that this term was not thoroughly understood. It was shown by Dr. H. Douvillé that the sequence in development of the foraminifera was from the nude forms to those with a chitinous test, then to the arenaceous, and finally to the perforate calcareous test. This sequence is borne out by comparative studies of great numbers of foraminifera. The chitinous base of many of the foraminifera from the Palaeozoic to Recent can be demonstrated by dissolving the outer layers when calcareous, or by sections where they are not. Lacroix has noted the inner chitinous layer of the Miliolidae and Textulariidae, and it is demonstrable in most of the simpler families, and even in the more primitive groups of the Rotaliidae, in the early chambers. Upon this chitinous base the arenaceous tests are built, as can be seen by careful study of any of these forms. It is very easy to understand the great amount of range in the material of arenaceous or agglutinated tests. Sand and mud are frequently employed, and with selection, mica flakes, sponge spicules, and other materials are used. The idea has arisen that arenaceous tests are characteristic of deep water, but they are extremely abundant in the warm, shallow waters of the tropics. The sand of coral reef regions is calcareous, and the arenaceous types of such habitats are of cal-

careous grains. Such forms as *Ammobaculites*, *Textularia*, *Bigenerina*, etc., are very highly developed and occur in enormous numbers in water of a fathom or so in depth. *Marsipella*, a primitive form, is often extremely abundant off the Florida coast in warm water, and is formed exclusively of sponge spicules with very little cement. Such primitive forms as *Webbinella*, *Iridia*, etc., are very common in similar habitats.

The cementing materials may be of various secretions and be siliceous or calcareous, often with what appears to be ferruginous material. Such reddish or brownish colored forms are found with their colors well preserved as far back as the Pennsylvanian. The amount of this cement may vary greatly even in different parts of the same individual test. *G'omospira* and *Ammodiscus* may be largely made of such cementing materials and the agglutinated grains be very few or very fine, and not noticed except with a considerable magnification. Many Palaeozoic forms show this same relation that occurs in the Mesozoic and in Recent forms of the same genera. The essential character of the test is one of agglutination, whether the percentage of cementing substance is very low or very high, and whether the particles used are large, rough fragments or very fine ones.

Many of the arenaceous calcareous forms may become perforate, and the development may be seen in a single individual. Sections of *Textularia* show the early chambers of closely agglutinated grains without pores, later chambers with a lining of secreted, calcareous, porous material, which in the adult may make a considerable proportion of the chamber wall, thus showing the development in the chambers of the same individual. In the Miliolidae, the more primitive genera all have species with arenaceous tests, as viewed from the exterior, but the arenaceous grains, calcareous, or siliceous, are only a surface coating with the smooth imperforate layer below. In the higher group of the Miliolidae, this power of building an arenaceous exterior is apparently lost. The primitive chitinous test is not as easily demonstrated in the more specialized Miliolidae as it is in the simpler, more primitive forms.

In Recent *Cyclammina*, there are all degrees of agglutination from tests of almost pure sand grains to others of almost pure cement with only occasional large grains or more numerous very fine ones. So in *Endothyra* in the Pennsylvanian and earlier there may be found a very parallel series. The arenaceous forms have held their relationships for very long periods. It is

not unusual to find *Hyperammina* or *Ammodiscus* with *Ammolagena* attached in the Pennsylvanian, in the Cretaceous and in the present ocean.

All these arenaceous or agglutinated tests, whatever the proportions of cement and fragmentary material, are to be distinguished from those tests of higher forms which are directly secreted by the protoplasm of the animal itself, and are of uniform structure. They have undoubtedly developed as shown by Douvillé from the habit of cementing materials together, and with attached forms which were capable of secreting their own tests, where waters had an abundance of calcium, there was no further need of agglutinated tests. Once the power of secreting the entire test was attained, there was brought into play the power of ornamentation of the test which has been carried to so great a development in the higher calcareous groups of the foraminifera. The complexity of chamberlets, the specialized structures such as the pillars and lateral and equatorial chambers of the Orbitoids, and the specialized spines of the Globigerinidae were impossible with the primitive arenaceous test. With the agglutinating of finer grained materials, very complex tests have been built up in the Fusulinidae and in such forms as the Orbitolinidae and Loftusiidae. A study of sections of large forms such as *Loftusia* is very interesting in showing in a single individual the development from a simple arenaceous test to one of a very considerable degree of complexity. The advance in complexity of structure in the arenaceous tests only came about when the animal used fine enough particles of foreign material to be subordinated to the architectural lines of the test. The highest calcareous forms secreted entirely by the animal overcame this handicap at once, and were able to build very beautiful and complex structures such as illustrated by *Lagena pulcherrima* (Pl. 2, fig. 10). In the matter of beauty of ornamentation, the Tertiary and Recent foraminifera far exceed anything in the earlier development of the group.

75. THE GENUS BOLIVINELLA AND ITS SPECIES

By JOSEPH A. CUSHMAN

This genus which was erected for Parker and Jones's species *Textularia folium* is now recorded from the Eocene to Recent, and is represented by several distinct species and varieties.

Genus BOLIVINELLA Cushman, 1927

Genoholotype, *Textularia folium* PARKER and JONES.

Bolivinella CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 2, 1927, p. 79; l. c., Special Publ. No. 1, 1928, p. 234.

Textularia (part) of authors.

Test much compressed, the proloculum in the megalospheric form rectangular, in the microspheric form the young apparently planispiral, later chambers biserial, chambers long and often recurved, not overlapping; wall calcareous, perforate; aperture transverse to the compression of the test with numerous papillae at the base of the opening.

Eocene to Recent.

The species are not related to *Textularia*, but are calcareous and perforate. The aperture instead of as in *Bolivina*, elongate in the plane of compression and somewhat comma-shaped, is low and widest in the plane at right angles to that of the compression of the test. The region about the aperture is covered with raised papillae and the whole area about the aperture sometimes projecting beyond the outline of that part of the test.

In all the species of the genus, the test is very strongly compressed and the flattened sides nearly parallel, some species with the median portion slightly convex. The chambers meet in the median line, usually with very little if any overlapping. Spines are developed in several forms, occasionally at the base but more often at the sides and independent of the individual chambers.

There are two records for "*Textularia folium*" from the Eocene of Biarritz, but the only figure is a somewhat incomplete one given by Liebus (Jahrb. Geol. Reichsanst., vol. 56, 1906, p. 356, fig. 2 (in text).) It is also recorded by Halkyard from the same locality (Mem. Proc. Manchester Lit. Philos. Soc., vol. 62, pt. 2, 1918 (1919), p. 32). Halkyard's notes are as follows:

"Rare, occurring only in Gatherings 8 and 9. The specimens are small, and the species is evidently not in a habitat favourable to its growth."

Heron-Allen and Earland in editing Halkyard's paper give the following: "(The main specimens though probably referable to *T. folium* can hardly be described as satisfactory, but a typical example occurs on one of the type slides. This appears to be the first fossil record of the species, but we have met with it (very rarely) in the Eocene of Spring Creek, Moorabool River, Victoria, where the specimens are curiously similar to those from Biarritz. The difference between these fossil specimens, and the Recent type is more probably due to development than to a starved habitat of the fossil specimens, which in our opinion are normally developed.)"

These records place the geologic history of the genus as far back as the Upper Eocene both of Europe and Australia. I have not found this species in the abundant material I have from Biarritz. This Eocene species must be left in a somewhat doubtful state until more material can be studied.

In the Oligocene both of America and Australia, there are forms belonging to the genus, and in the Miocene of Europe and Australia. In the present oceans, the genus is confined to the Indo-Pacific with a somewhat restricted distribution even in that faunal area.

RECENT SPECIES

BOLIVINELLA FOLIA (Parker and Jones) Plate 5, figures 1, 2

Textularia folium PARKER and JONES, Philos. Trans. Roy. Soc., vol. 155, 1865, pp. 370, 420, pl. 18, fig. 19.—MOEBIUS, Beitr. Meeresfauna Insel Mauritius, 1880, p. 92, pl. 8, figs. 16, 17.—H. B. BRADY (in part), Rep. Voy. Challenger, Zoology, vol. 9, 1884, p. 357, pl. 42, figs. 3-5 (not 1, 2).—EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 272, pl. 6, figs. 27, 28.—CHAPMAN, Journ. Linn. Soc. London (Zoology), vol. 28, 1900 (1902), p. 184.—RHUMBLER, Zool. Jahrb., Abteil. Syst., vol. 24, 1906, p. 59, pl. 5, figs. 51, 52.—CHAPMAN, Journ. Quekett Micr. Club, ser. 2, vol. 10, 1907, p. 127, pl. 9, fig. 4.—BAGG, Proc. U. S. Nat. Mus., vol. 34, 1908, p. 130.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 2, 1911, p. 19, figs. 31-33 (in text).—HERON-ALLEN and EARLAND, Trans. Zool. Soc. London, vol. 20, 1915, p. 623.—CUSHMAN, Publ. 342, Carnegie Instit. Washington, 1924, p. 12, pl. 7, fig. 2.—HERON-ALLEN and EARLAND,

Journ. Linn. Soc. Zool., vol. 35, 1924, p. 617.—CUSHMAN, Bernice P. Bishop Mus., Bull. 27, 1925, p. 123.

Bolivinella folium CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 2, 1927, p. 79; 1. c., Special Publ. No. 1, 1928, p. 234, pl. 33, figs. 15, 16; pl. 34, fig. 8.

Test free, very much compressed, broad and triangular in front view, the apertural end usually broadly convex, in end view narrow, widest near the middle, thence tapering toward the rather acute lateral margins; chambers broad and low in the adult, in two alternating series, somewhat curved; sutures thickened, in the later portion usually somewhat sigmoid, median line with a slightly raised median suture; wall rather coarsely perforate; proloculum rounded or quadrangular, periphery often with spines at the outer angles or sometimes at the sides, independent of the individual chambers. Length usually not more than 0.5 mm.

There are numerous records for this species in the Indo-Pacific region where it is one of the typical species of warm shallow water in coral-reef conditions. The following records are probably of this species: shore sand, Melbourne (Parker and Jones); Mauritius, rare, from the intestine of *Mareta planulata* (Moebius); off East Moncoeur Island, Bass Strait, 38 fathoms off Raine Island, Torres Strait, 155 fathoms; off Kandavu, Fiji 255 fathoms; off Levuka, Fiji; Nares Harbor, Admiralty Islands, 17 fathoms; Honolulu coral-reefs, 40 fathoms (H. B. Brady); Mauritius and East Australia (Egger); from the lagoon

EXPLANATION OF PLATE 5

All figures $\times 100$

FIGS. 1, 2. *Bolivinella folia* (Parker and Jones). Fig. 1, From Fiji. Fig. 2, From off Necker Id.

FIGS. 3, 4. *Bolivinella folia* (Parker and Jones), var. *ornata* Cushman, n. var. From shore sand, Hardwicke Bay, Australia. Fig. 3. Two plastogamic individuals.

FIG. 5. *Bolivinella margaritacea* Cushman, n. sp. Miocene, near Bordeaux.

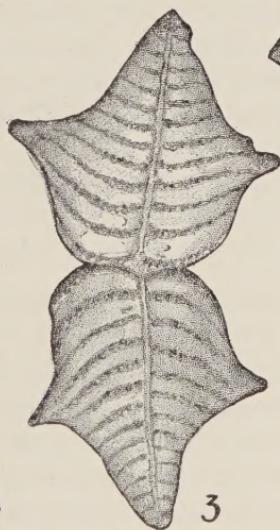
FIGS. 6, 7. *Bolivinella australis* Cushman, n. sp. Australia. Fig. 6, Miocene. Fig. 7, Oligocene.

FIG. 8. *Bolivinella subpectinata* Cushman, n. sp. Lower Oligocene, Byram, Mississippi.

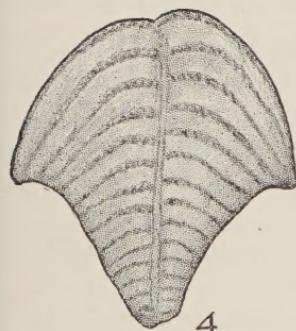
FIG. 9. *Bolivinella virgata* Cushman, n. sp. Miocene, near Bordeaux.



1



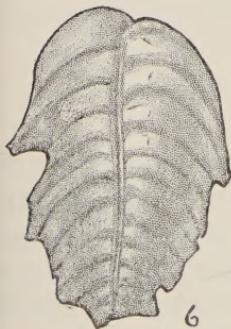
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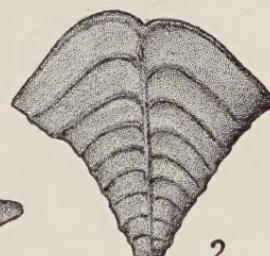
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6



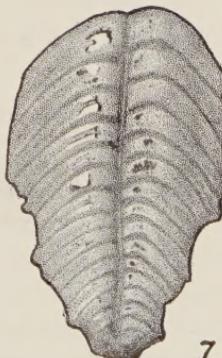
9



2



5



7

at Funafuti; shore sands of Victoria (Chapman); shallow water off Laysan Island (Rhumbler); off the Hawaiian Islands, 30 fathoms (Bagg); 249 and 271 fathoms (Cushman); a single specimen from the Kerimba Archipelago, 5 to 10 fathoms (Heron-Allen and Earland), Lord Howe Island (Heron-Allen and Earland), a single specimen; Philippines; and Hawaii to Midway Island (Cushman).

In this species, the outer curve of the sutures is often sigmoid as shown in the figures. It may be noted that the type figure is not as definite in its details as later ones.

BOLIVINELLA FOLIA (Parker and Jones), var. **ORNATA** Cushman, new variety
Plate 5, figures 3, 4

Test somewhat similar to the typical form but the apertural end much more convex, the sides typically with a large, stout spine at either side, the sutures broadly limbate and raised throughout into a fine beaded ornamentation, the median line slightly raised but not markedly so.

Holotype of variety (Cushman Coll. No. 10482) from shore sand, Hardwicke Bay, Australia.

This variety may be one of those figured by Brady in the *Challenger* report from Bass Strait, Australia, but sufficient details are not given. Plastogamous specimens are not uncommon in this species. One pair is figured here.

Specimens are also in my collection from the Post-tertiary of Bore No. 5, Boneo, Victoria, Australia sent me by Mr. W. J. Parker (Cushman Coll. No. 10487).

BOLIVINELLA AUSTRALIS Cushman, new species
Plate 5, figures 6, 7

Test elongate, early portion rapidly broadening, later portion with the sides nearly parallel in the adult, outline somewhat irregular, with or without spinose processes; chambers curved, sutures distinct, limbate, curved but not sigmoid, unornamented median line marked by a long straight furrow with slightly raised sides, the line of union between the chambers concealed by this ridge. Length 0.45 mm.; breadth 0.30 mm.

Holotype (Cushman Coll. No. 5550) from Oligocene, Clifton Bank, near Hamilton, Victoria, Australia. I also have the species from the Miocene of Australia, 85-150 feet in bore at

Hopevale Station, near Geelong, Victoria, Australia from W. J. Parr.

It may be noted here that Brady's figures in the *Challenger* report, Pl. 42, fig. 1 and perhaps fig. 2 from Bass Strait, may be this species. The sides of this species are not nearly as spreading as in *B. folia* and the central channel is very distinctive. It is nearest to the following species from the Miocene of France, a relation not unusual as many forms of the two areas show close relationships.

BOLIVINELLA MARGARITACEA Cushman, new species
Plate 5, figure 5

Test elongate, whole test very gradually broadening as chambers are added, sides usually irregularly indented and with irregular spinose projections of small size or wanting; chambers gently curved, the last one slightly sigmoid; sutures limbate, slightly raised, the earlier ones only slightly curved, later ones tending to become sigmoid and irregularly beaded, median line with a very slightly channelled ridge. Length of holotype 0.38 mm.; breadth 0.20 mm.

Holotype (Cushman Coll. No. 10484) from Miocene of Pont Gourguet, Saucats, near Bordeaux, France.

This species is nearest to *B. australis*. The median range is much less marked and the channel less prominent, the sutures and chambers are less curved, and the later sutures beaded. It is not uncommon in this Miocene material. It occurs also in the Miocene from Cabanes, St. Paul de Dax, near Bordeaux.

BOLIVINELLA VIRGATA Cushman, new species
Plate 5, figure 9

Test small, slender, much longer than broad, sides nearly parallel for most of their length, without spinose projections, thickened in the middle, thence tapering to the acute periphery; chambers slightly curved, increasing gradually in height as added; sutures strongly limbate, broad, evenly curved, apertural end finely papillate; wall smooth. Length 0.25-0.30 mm.; breadth 0.15 mm.

Holotype (Cushman Coll. No. 10478) from Miocene, Pont Gourguet, Saucats, near Bordeaux, France.

This is a thicker, smaller species than any of the others, but

the apertural characters place it in this genus. It is rare at the type locality, but constant in its characters.

BOLIVINELLA SUBPECTINATA Cushman, new species
Plate 5, figure 8

Textularia folium CUSHMAN (not PARKER and JONES), Journ. Washington Acad. Sci., vol. 10, 1920, p. 199; U. S. Geol. Survey, Prof. Paper 129-E, 1922, p. 90, pl. 14, fig. 3; Prof. Paper 133, 1923, p. 18. *Bolivinella folium* HOWE, Journ. Pal., vol. 2, 1928, p. 174 (list).

Test small, roughly rhomboid, widest at the base of the last formed chambers, very much compressed, sides nearly flat, chambers numerous, strongly curved; sutures slightly limbate, strongly raised above the general surface of the test, confluent in a zig-zag line along the median line of the test, projecting somewhat at the peripheral margins forming a subpectinate edge; walls and sutures smooth. Length 0.50 mm.; breadth 0.4 mm.

Holotype (Cushman Coll. No. 10480) from Lower Oligocene Byram calcareous marl, Byram, Mississippi. The species is found at several stations in the Byram marl, and Dr. Howe has recorded it from the Red Bluff clay, therefore its range is probably throughout the Lower Oligocene of Mississippi.

It can be distinguished from the other species of the genus by the lack of a median ridge or channel and the subpectinate border with strongly raised, narrow sutures.

76. ON GUTTULINA LACTEA (WALKER AND JACOB)
POLYMORPHINA BURDIGALENSIS D'ORBIGNY
AND PYRULINA GUTTA D'ORBIGNY

By YOSHIAKI OZAWA

Sixty years have passed since Brady, Parker and Jones untangled the great confusion existing in the nomenclature of the Polymorphinidae. They apparently fixed all the species known till 1869, and arranged them as they considered in something

like a natural sequence. The nomenclature of the Polymorphinidae appears still to offer much difficulty. We are now trying to fix and rearrange the hitherto known species by examining topotype specimens as far as possible. The above cited three species, among the older ones of the Polymorphinidae, are of much importance, and are described here. The synonymy and geological and geographical distribution of these species are omitted in this paper. In examining d'Orbigny's original specimens in the Paleontological Department of the Museum of Natural History, Jardin des Plantes in Paris, I found that the originals of *Polymorphina burdigalensis* and *Pyrulina gutta* are lost.

POLYMORPHINA BURDIGALENSIS d'Orbigny
Plate 6, figures 1-3

Polymorphina burdigalensis D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826,
p. 265, no. 2; Model no. 29.

Polymorphina burdigalensis D'ORBIGNY, var. *lequillensis* FORNASINI,
Mem. Istit. Bologna Acad. Sci., ser. 5, tomo 9 (1900-1902), p. 73,
fig. 26.

Test fusiform to oblong, more or less flattened on one side, unsymmetrically convex on the other; chambers elongate, more embracing on the flattened side, arranged in an almost biserial series from the start; sutures scarcely depressed, distinct; wall smooth, translucent; aperture radiate.

I found that d'Orbigny's original specimen deposited in the Paleontological Department, Museum of Natural History, Jardin des Plantes in Paris, is lost, and the species has been neither figured nor described by d'Orbigny, therefore the only reference having any authority is a plaster model. Brady, Parker and Jones figured a model of *Polymorphina burdigalensis* in their Monograph, but as far as the figures are concerned, their model is different from that in the Cushman Laboratory, because those figures are the reverse of that form shown by this model; but all the models of *Polymorphina burdigalensis* including that in the British Museum of Natural History which I have examined, are just the same as this. Apparently this reversal came in the drawing of the figures, a similar reversal being shown in other species in Brady, Parker and Jones' Monograph. According to the "Tableaux Méthodique", d'Orbigny's specimen was obtained from the Miocene in the environs of Bordeaux. I have examined much material from the same locality, as well as from Dax,

and only one specimen somewhat resembling the model was found. The specimen figured here is just the same as *Polymorphina burdigalensis*, at least in the degree of embracing of the elongate chambers and an unequal compression on each side of the test, although the arrangement of chambers is not as regular as shown by the model which should be considered to be somewhat conventionalized.

Fornasini's *Polymorphina burdigalensis*, var. *lequileensis*, obtained from Lequile, is almost the same as ours, and his figures are copied here for comparison.

The locality of our figured specimen is Miocene (Burdigalien) Moulin de l'Eglise, Saucats, (Gironde), France.

GUTTULINA LACTEA (Walker and Jacob)

Plate 6, figures 6-10

Serpula tenuis ovalis laevis WALKER and JACOB, Test. Min., 1784, p. 2, pl. 1, fig. 5.

Serpula lactea WALKER and JACOB, fide Kanmacher, Adams' Essays, 2nd Ed., 1798, p. 634, pl. 24, fig. 4.

Polymorphina lactea (typica) WILLIAMSON (part), Rec. Foram. Gt. Britain, 1858, p. 71, pl. 6, fig. 147.

Test ovate, roundly triangular in section, tapering but little, rounded at base; chambers elongate, somewhat compressed, ar-

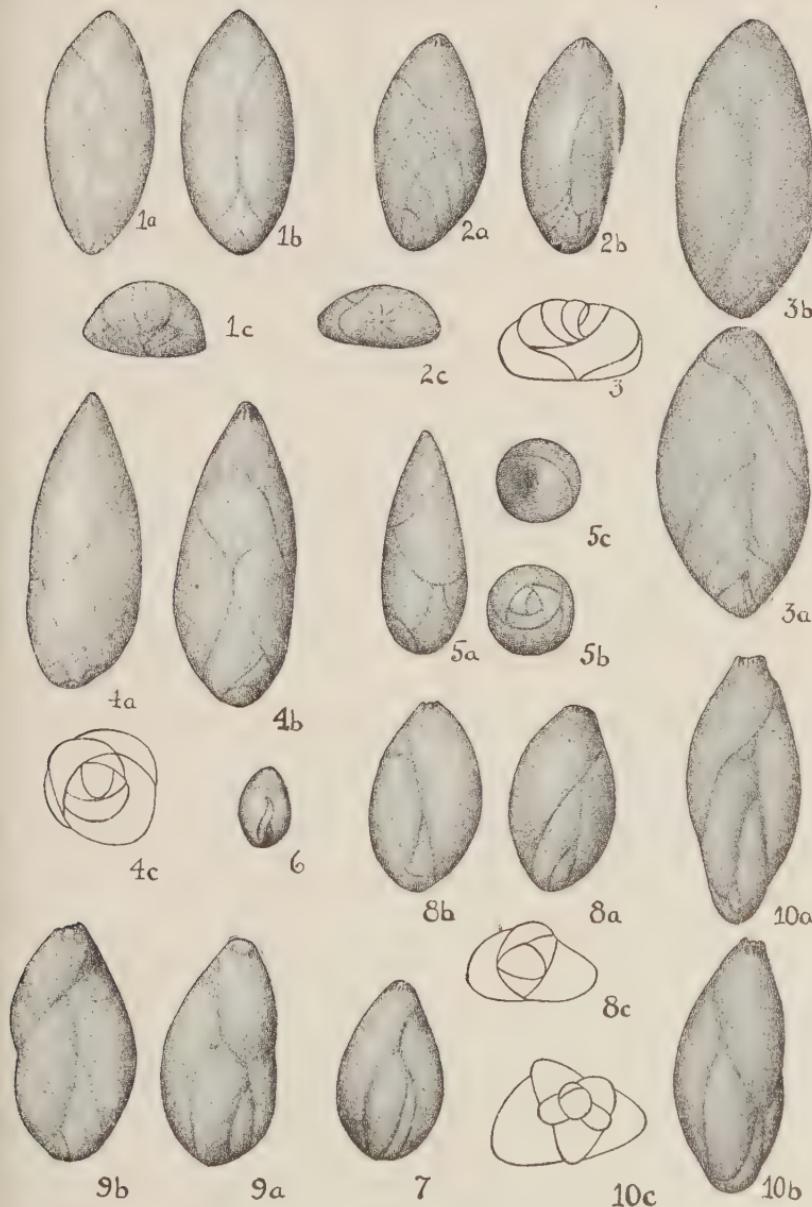
EXPLANATION OF PLATE 6

Figs. 1-3. *Polymorphina burdigalensis* d'Orbigny. Fig. 1, Figured from the model in the Cushman Laboratory. Fig. 2, Copied from Fornasini's figures of *Polymorphina burdigalensis*, var. *lequileensis*. Fig. 3, Topotype specimen.

Figs. 4, 5. *Pyrulina gutta* d'Orbigny. Fig. 4, Specimen from Wansin, Belgium. Fig. 5 a, b, Copied from d'Orbigny's original figures. Fig. 5 c, Copied from Brady, Parker and Jones' figure.

Figs. 6-10. *Guttulina lactea* (Walker and Jacob). Fig. 6, Copied from Walker and Jacob's original figure. Fig. 7, Copied from Williamson's *Polymorphina lactea typica* (fig. 147). Figs. 8-10, Three different specimens obtained from 37½ fathoms, off Bantry Bay, S. W. Ireland. 8, More common form. 9, Specimen having one more chamber than the former. 10, More elongate specimen.

Figures drawn by Margaret S. Moore



ranged in a contra-clockwise quinqueloculine series, often tending to become a sigmoid series, each succeeding chamber very slightly removed from the base; sutures depressed, distinct; walls smooth, translucent; aperture radiate.

This is the earliest figured species belonging to the family of Polymorphinidae, obtained in the sand of the sea-shore near Sandwich, England. Although the figure is small and can hardly be considered to be drawn well, and moreover the description is very simple, yet they are sufficient to show that the figured specimen has a rather compressed test, the chambers of which are arranged in a contra-clockwise quinqueloculine series, and in these respects, it has just the same characters as one of the forms figured by Williamson in his *Foraminifera of Great Britain* (pl. 6, fig. 147).

Williamson's other two figures named *Polymorphina lactea* are different from fig. 147 in their acute initial end and biserial arrangement of later chambers; they are similar to *Polymorphina subcompressa* d'Orbigny (= *Polymorphina compressa* d'Orbigny). Such a biserial *Polymorphina* is also described by Fleming under the name of *Vermiculum lacteum* as early as 1822.

Williamson's figure is well drawn, and was taken by Brady, Parker and Jones as a typical specimen representing *Polymorphina lactea* in their Monograph of the Genus *Polymorphina*. Brady, Parker and Jones apparently fixed the species very well, but they placed many different species in the synonymy of *Polymorphina lactea* which led later authors into confusion, and since the publication of their paper, the name of *Polymorphina lactea* has been used very often, and accordingly the species has been mistaken. Probably no other species in the foraminifera has been more misunderstood than the present species.

We have examined shallow sea foraminiferal material obtained from off England, Ireland and Iceland, and isolated many specimens which can be identified with *Polymorphina lactea* which are tolerably definite in their essential characters,—ventricose test with depressed sutures, the elongate chambers arranged in a contra-clockwise, quinqueloculine series,—but often the test tends to become compressed by losing the quinqueloculine arrangement of chambers, that is, the latter chambers having a tendency to become arranged in a sigmoid series.

PYRULINA GUTTA d'Orbigny

Plate 6, figures 4, 5

Polymorphina (Pyrulina) gutta d'ORBIGNY, Ann. Sci. Nat., vol. 7, 1926, p. 267, no. 28, pl. 12, figs. 5, 6; Modèle no. 30.

Polymorphina (Globulina) clavata ROEMER, Neues Jahrb. für Min., Jahrg. 1838, p. 386, pl. 3, fig. 38.

Test clavate, rounded at the base, tapering towards the apertural end, margin entire; chambers rounded, embracing, arranged at first in an almost triserial series tending to become biserial; sutures not depressed, distinct; wall smooth; aperture radiate, pointed.

The original specimen (in Paleontological Department, Museum of Natural History, Jardin des Plantes, Paris) is lost.

d'Orbigny's figures represent the species fairly well, although his basal view showing the arrangement of chambers is not well drawn as far as a figure of a side view is concerned. d'Orbigny's specimen was obtained from the Pliocene at Castel-Arquato. We have examined material from the same locality, but we could not obtain any specimen resembling his species. The specimen figured here was found in the Eocene material from Wansin in Belgium, and the specimen is very much like d'Orbigny's model in every respect. Our specimen presents an arrangement of chambers not strictly triserial, at first somewhat triserial, but later tending to become biserial. As d'Orbigny's original specimen is lost and his figure of the basal view apparently is not well drawn, the figure showing the side view is the only means of knowing how the chambers of d'Orbigny's specimen are arranged. Judging from his figure, at least the later chambers of his species appear to be arranged in an almost biserial series which seems to be the usual arrangement in a group of elongate cylindrical Polymorphinidae.

d'Orbigny compared his species with Soldani's *Polymorphium pyriformium* figured in *Testaceographia*. Soldani's specimen resembles *Pyrulina gutta* in its shape, but judging from the figure, it seems to have less chambers and it might be considered to be a young stage of *Pyrulina gutta*, but it is characterized by a peculiar sigmoid suture, and in this point it is quite distinct from *Pyrulina gutta*, therefore it is advisable not to place it in the synonymy of *P. gutta*.

On the other hand, *Polymorphina (Globulina) clavata* figured by Roemer from the German Middle Oligocene, considered from his figure, resembles much *Pyrulina gutta*.

77. NOTES ON THE FORAMINIFERA OF THE BYRAM MARL

By JOSEPH A. CUSHMAN

Since the publication of the two papers "The Foraminifera of the Byram Calcareous Marl at Byram, Mississippi" (U. S. Geol. Survey Prof. Paper 129-E, 1922) and "The Foraminifera of the Vicksburg Group" (U. S. Geol. Survey Prof. Paper 133, 1923), numerous additions to the fauna of the Byram marl have been found from time to time. Some of these seem worthy of record. New material has come to hand from various sources among which may be noted a small packet of excellent material from the type locality collected by Mrs. Helen Jeanne Plummer. That the fauna of the Vicksburg, especially its varied members, may be much enlarged by further collection, was shown by Dr. Henry V. Howe "Additions to the List of Species Occurring in the Type Red Bluff Clay, Hiwanee, Mississippi" (Journ. Pal., vol. 2, 1928, pp. 173-176).

Only some of the more interesting additions are noted here.

MASSILINA DECORATA Cushman
Plate 7, figure 1

Massilina decorata CUSHMAN, U. S. Geol. Survey Prof. Paper 129, 1922, p. 143, pl. 34, fig. 7; Prof. Paper 133, 1923, p. 55.

This species is most characteristic and abundant in the Red Bluff clay, but occasional specimens occur in the Byram marl. Like its living closely related forms, it seems to have been more abundant in water of some considerable depth such as represented by the Red Bluff clay rather than in shallow water as represented by the Byram marl.

TRILOCULINA SCULPTURATA Cushman
Plate 7, figure 2

Triloculina sculpturata CUSHMAN, U. S. Geol. Survey Prof. Paper 129, 1922, p. 143, pl. 33, figs. 4, 5; Prof. Paper 133, 1923, p. 57.

This species known previously from the Mint Spring marl occurs also in the Byram marl. It should be noted that Dr.

Howe did not record this species from the Red Bluff clay, and it is evidently a species of shallow water habitat.

POLYMORPHINA FRONDEA (Cushman)

Bolivina frondea CUSHMAN, U. S. Geol. Survey Prof. Paper 129, 1922, p. 126, pl. 29, fig. 3; Prof. Paper 133, 1923, p. 20.

This species was described as a *Bolivina* due largely to the very poor state of preservation of the earlier specimens available for study. The aperture was invariably broken. Later more numerous specimens were found in the Byram marl which were well preserved and with the apertural characters complete. It is thus shown to be a true *Polymorphina* with a small radiate aperture and regularly alternating chambers. The specimens from the Byram marl complete the records for its occurrence in all the members of the Vicksburg group. It is not as rare as at first thought, and with modern methods of preparing material, good series may be obtained.

POLYMORPHINA ADVENA Cushman

Plate 7, figure 5

Polymorphina advena CUSHMAN, U. S. Geol. Survey Prof. Paper 129, 1922, p. 132, pl. 31, fig. 4.

This is a rather beautifully ornamented form in which the chambers are ornamented by fine longitudinal costae, nearly parallel to the long axis of the test and often becoming obsolete in the later chambers in the adult. Originally described from the Mint Spring marl, it is now recorded from the Byram marl and is probably to be expected with *Polymorphina frondea* in the other members of the Vicksburg series.

LAGENA BYRAMENSIS Cushman, new species

Plate 7, figures 3 a, b

Test nearly circular in front view, surrounded by a thin, broad keel of nearly transparent material, the body of the test strongly convex and marked by a series of raised costae, the outer ones nearly concentric, the inner ones gradually approaching the direction of the longitudinal axis of the test; apertural end squarely truncate. Diameter 0.25 mm.

Holotype (Cushman Coll. No. 10507) from the Lower Oligocene, Byram marl of Byram, Mississippi.

This is a rather frequent species of the Byram marl, and the characters of the ornamentation are very constant.

BULIMINELLA SUBTERES (H. B. Brady), var. ANGUSTA Cushman
Plate 7, figure 4

Buliminella subteres (H. B. Brady), var. *angusta* Cushman, U. S. Geol. Survey Prof. Paper 129, 1922, p. 127, pl. 29, figs. 8, 9; Prof. Paper 133, 1923, p. 24.

There are specimens in the Byram marl similar to those previously found and recorded from the Mint Spring marl. One such specimen is figured here to show the difference between this and the other two species noted below.

BULIMINELLA OBTUSATA Cushman, new species
Plate 7, figures 8 *a*, *b*

Test elongate, the sides nearly parallel for most of their length, two or three times as long as broad, coils few; chambers numerous, distinct, ten or more in the last-formed coil, but not inflated; sutures distinct, not depressed, rather evenly curved, slightly imbricate; wall smooth, polished; aperture large, in a slight depression of the apertural face, the upper end rounded, thence tapering to the base. Length 0.40 mm.; breadth 0.15 mm.

EXPLANATION OF PLATE 7

All figures $\times 120$

FIG. 1. *Massilina decorata* Cushman. Side view of young specimen of more than the usual involution.

FIG. 2. *Triloculina sculpturata* Cushman.

FIGS. 3 *a*, *b*. *Lagena byramensis* Cushman, new species. *a*, side view; *b*, apertural view.

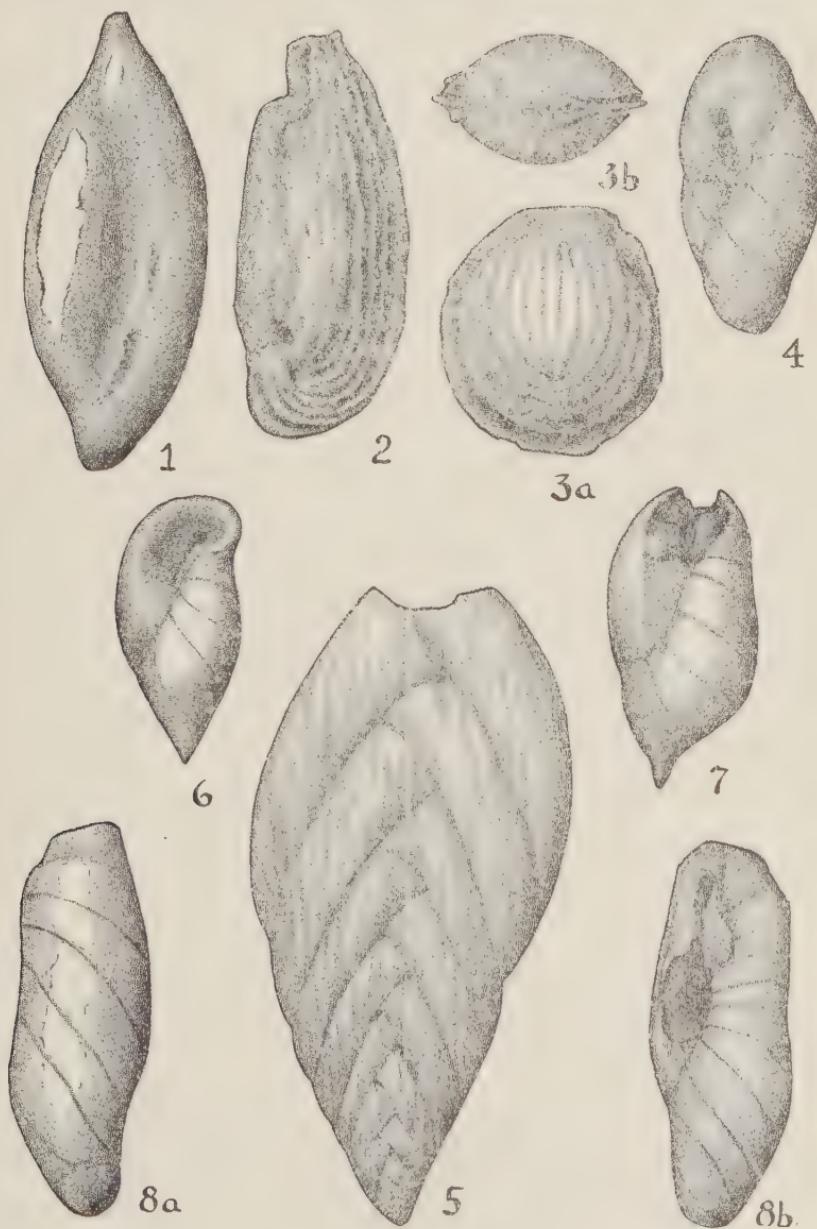
FIG. 4. *Buliminella subteres* (H. B. Brady), var. *angusta* Cushman.

FIG. 5. *Polymorphina advena* Cushman.

FIGS. 6, 7. *Buliminella apiculata* (Chapman). Apertural views of two different specimens.

FIGS. 8 *a*, *b*. *Buliminella obtusata* Cushman, new species. *a*, *b*, opposite sides.

Figures drawn by Margaret S. Moore



Holotype (Cushman Coll. No. 10501) from Lower Oligocene, Byram marl from Byram, Mississippi.

The figured specimen has the apertural region broken, but other specimens show this character more completely. Some of the other specimens are even more slender. The very even outline, elongate form, few whorls, many chambers, and limbate sutures will distinguish this species from others of the group.

BULIMINELLA APICULATA (Chapman)

Plate 7, figures 6, 7

Bulimina elegantissima d'ORBIGNY, var. *apiculata* CHAPMAN, Journ. Linn. Soc., Zoology, vol. 30, 1907, p. 31, pl. 4, fig. 77; Subantarctic Islands of New Zealand, Wellington, 1909, p. 330; Zool. Res. "Endeavour", vol. 3, pt. 1, 1915, p. 18.—SIDEBOTTOM, Journ. Roy. Micr. Soc., 1918, p. 123, pl. 3, fig. 11.

Buliminella elegantissima (d'ORBIGNY), var. *apiculata* CUSHMAN, Publ. 342, Carnegie Instit. Washington, 1924, p. 25.

After having studied large numbers of *Buliminella elegantissima* from the type region off the West coast of South America, it seems very certain that the form described by Chapman is specifically distinct. The base has a distinct spine and the shorter, broader form is unlike typical *B. elegantissima*. It is another example of the similarity in species between the fauna of the Byram marl and that of the present Indo-Pacific region.

**LOXOSTOMUM AMYGDALAEFORMIS (H. B. Brady), var. *DELICATA* Cushman,
new variety**

Plate 8, figure 2

Bolivina amygdalaeformis CUSHMAN (not H. B. BRADY), Journ. Washington Acad. Sci., vol. 10, no. 7, 1920, p. 199; U. S. Geol. Survey Prof. Paper 129-E, 1922, p. 91, pl. 15, fig. 3; Prof. Paper 133, 1923, p. 18.

Variety differing from the typical in the much more delicate ornamentation, the costae being finer and much more numerous, and the entire test tending to become more compressed, the periphery often subacute; aperture in the adult becoming terminal. Length 0.60 mm.; breadth 0.30 mm.; thickness 0.15 mm.

Holotype of variety (Cushman Coll. No. 10495) from Byram marl, Byram, Mississippi.

This variety which has previously been referred to *Bolivina amygdalaeformis* H. B. Brady is different from the typical form

as developed in the present ocean in the Indo-Pacific region. The last-formed chamber is usually bare of ornamentation and distinctly perforate, the earlier portion being entirely covered with a series of very delicate, longitudinal costae, anastomosing freely. The typical form is much more rounded and is coarser in all its aspects.

BIFARINA VICKSBURGENSIS (Cushman)

Plate 8, figures 3, 4

Bolivina vicksburgensis CUSHMAN, U. S. Geol. Survey Prof. Paper 129, 1922, p. 126, pl. 29, fig. 2; Prof. Paper 133, 1923, p. 20.

The original specimens described as *Bolivina vicksburgensis* were incomplete, probably young stages. The adult stage is uniserial as shown on Plate 8, figures 3, 4. The chambers are slightly compressed, the aperture elliptical, terminal, with a slightly raised lip. The surface is coarsely perforate, the perforations often arranged in longitudinal lines, especially in the earlier portion. The periphery is serrate in the young. Originally described from the Mint Spring marl, this species is now known from the Glendon limestone and the Byram marl. The specimens figured here are from Byram, Mississippi.

TUBULOGENERINA APERTA Cushman, new species

Plate 8, figures 1 a, b

Gaudryina sp. ? CUSHMAN, U. S. Geol. Survey Prof. Paper 129, 1922, p. 127, pl. 29, fig. 6.

Test small, with the early chambers biserial or the earliest possibly triserial, in the adult tending to become uniserial, slightly compressed in transverse section; chambers numerous, inflated, distinct; sutures depressed, fairly distinct; wall ornamented with spinose projections, in well preserved specimens, elongate and apparently tubular, scattered over the entire surface of the test, especially well developed in the later chambers; aperture large, circular, terminal, with a raised border. Length 0.35-0.40 mm.; breadth 0.12-0.15 mm.; thickness 0.08-0.10 mm.

Holotype (Cushman Coll. No. 10492) from Lower Oligocene, Byram calcareous marl, Byram, Mississippi.

This species occurs in some numbers at Byram, but is small

and easily overlooked. Well preserved, adult specimens show the tubular character of the spinose projections. It also occurs sparingly in the Mint Spring marl.

The best development of this genus is in the Eocene of Europe and the Miocene of Australia, although the earliest known species came from the Cretaceous. The American species is a fairly simple one structurally.

SIPHONINELLA BYRAMENSIS Cushman, new species
Plate 8, figures 5 a-c

Test small, trochoid, nearly equally biconvex, last-formed one or two chambers tending to uncoil, periphery slightly keeled; chambers distinct, five or six in the last-formed coil, the last one or two slightly inflated as uncoiling takes place; sutures strongly oblique on the dorsal side, slightly curved on the ventral side, slightly limbate, not depressed except on the ventral side between the last-formed chambers; wall smooth on the dorsal side except along the keel which is slightly beaded, ventral side with the basal angle of the last-formed chambers distinctly beaded, otherwise nearly smooth; aperture in the early portion as in *Siphonina*, in the later uncoiled chambers, the aperture away from the edge of coiling, subterminal, elliptical with a distinct lip. Diameter 0.25 mm.; thickness 0.10 mm.

Holotype (Cushman Coll. No. 10500) from Lower Oligocene, Byram calcareous marl, Byram, Mississippi.

EXPLANATION OF PLATE 8

All figures $\times 120$

Figs. 1 a, b. *Tubulogenerina aperta* Cushman, new species. a, side view; b, apertural view.

FIG. 2. *Loxostomum amygdalaeformis* (H. B. Brady), var. *delicata* Cushman, new variety.

Figs. 3, 4. *Bitavina vicksburgensis* (Cushman). Fig. 4, Complete specimen becoming uniserial. Fig. 3, Portion of apertural end, showing more uniserial chambers.

Figs. 5 a-c. *Siphoninella byramensis* Cushman, new species. a, dorsal view; b, ventral view; c, peripheral view.

Figs. 6 a-c. *Asterigerina bracteata* Cushman, new species. a, dorsal view; b, ventral view; c, peripheral view.

Figures drawn by Margaret S. Moore



1b



1a



2



3



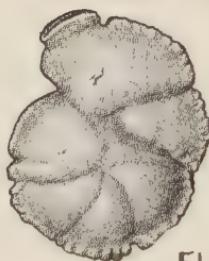
4



5a



5c



5b



6a



6c



6b

This is one of the most interesting species of the Byram marl. The other two species of the genus are *Siphoninella claibornensis* Cushman and Howe (Contr. Cushman Lab. Foram. Res., vol. 3, 1927, p. 120, pl. 24, figs. 8-10) and *Siphoninella soluta* (H. B. Brady) figured in the *Challenger Report*, pl. 96, figs. 4 a-c. The Claiborne species of the Eocene described from Louisiana has a fimbriate periphery and the uncoiling is strongly developed, the chambers in the coil fewer, and there is no raised ornamentation of the general surface.

In *Siphoninella soluta* (H. B. Brady) which is known only from the West Indian region, in fairly deep water, the relationship to *S. byramensis* is much closer. The Recent species has many of the characters of the Oligocene one, the ventral side being very similar. The dorsal side in the Recent species is highly ornamented and uncoiling is carried to a higher degree. The form and position of the aperture is very similar in the two species. It is evident that the Recent species is directly derived from the Oligocene one.

ASTERIGERINA BRACTEATA Cushman, new species
Plate 8, figures 6 a-c

Test small, scale-like, plano-convex, ventral side flat or even slightly concave, dorsal side moderately convex, periphery acute, somewhat keeled; chambers distinct, five or six in the last-formed coil, ventrally with angular, supplementary chambers coming in between the regular series, rhombic in outline, giving a stellate appearance to the base of the test; sutures on the dorsal side strongly curved, not depressed, slightly limbate, ventrally with the sutures a little depressed; wall finely perforate dorsally, somewhat more coarse on the ventral side, smooth; aperture very narrow, ventral. Diameter 0.22-0.30 mm.; height 0.15-0.18 mm.

Holotype (Cushman Coll. No. 10504) from Lower Oligocene, Byram calcareous marl, Byram, Mississippi.

This is a small scale-like species that on account of its small size may be easily overlooked. Unlike many of the other species of *Asterigerina* which are more convex on the ventral side, this is nearly flat at the base and convex dorsally. In this respect, it is more like the species from the Miocene of the Vienna Basin.

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works that have come to hand.

Yabe, Hisakatsu and Shoshiro Hanzawa.

Tertiary Foraminiferous Rocks of Taiwan (Formosa).

(Proc. Imper. Acad., vol. IV, no. 9, 1928, pp. 533-536, text figs. 1-3.) *Tokyo.*

Preliminary notes are given on a study of this material with descriptions and figures of two new forms and a new subgenus *Myogypsinoides*.

Hanzawa, Shoshiro.

Preliminary Report on Marine Deposits from the Southwest-ern North Pacific Ocean.

(Rec. Ocean. Works in Japan, vol. 1, no. 2, Oct., 1928, pp. 59-77, pls. xvi-xxi, with map.) *Tokyo.*

Lists of foraminifera are given, and the plates show typical assemblages.

Galloway, J. J. and Margaret Morrey.

A Lower Tertiary Foraminiferal Fauna from Manta, Ecuador.

(Bull. Amer. Pal., vol. 15, no. 55, Jan. 3, 1929, pp. 1-56, pls. 1-6.) *Ithaca.*

A fauna referred by the authors to the Upper Eocene is figured and described with 10 new species and 1 new variety.

Silvestri, Alfredo.

I Foraminiferi.

(Res. Sci. Miss. Oasi Giarabub, 1926-1927 (1928), pp. 171-199, pls. 27-31, 1 text fig.) *Rome.*

Copious notes with references and numerous sections are given of numerous species from this part of Africa.

Berry, E. Willard.

The Foraminifera of the Restin Shale of Northwest Peru.

(Eclogae geologicae Helvetiae, vol. 21, no. 1, 1928, pp. 130-135, 6 text figs.) *Basel.*

There are 26 species and varieties listed, of which 6 are described as new.

Tobler, A.

Über *Pseudocyclammina* and *Choffatella* in Schweizerischen Juragebirge.

(Eclogae geologicae Helvetiae, vol. 21, no. 1, pp. 212-216, pl. 24.) *Basel.*

One new species is described and figured, notes given and literature cited.

Berry, E. Willard.

The Smaller Foraminifera of the Middle Lobitos Shales of Northwestern Peru.

(Eclogae geologicae Helvetiae, vol. 21, no. 2, 1928, pp. 390-405, with 27 text figs.) *Basel.*

26 out of 75 species listed are described as new. The figures are line drawings appearing as text figures.

Berry, E. Willard.

Asterodiscocyclina, a new Subgenus of *Orthophragmina*.

(l. c., pp. 405-407, pl. 33.) *Basel.*

This new subgenus with a new species is from the Upper Eocene of Peru.

Umbgrove, J. H. F.

Het genus *Pellatispira* in het indo-pacifische gebied (with summary in English).

(Wetensch. Med., Mijn. Ned.-Ind., no. 10, 1928, pp. 1-60, 16 pls., 10 text figs.) *Weltevreden.*

An exhaustive treatment of the species of the genus as it occurs in the Indo-Pacific with several new species and many figures showing sections and structure.

Franke, A.

Die Foraminiferen der Oberen Kreide Nord-und Mitteldeutschlands.

(Abhandl. Preuss. Geol. Landes., vol. 111, 1928, pp. 1-207, pls. 1-18, 2 text figs.) *Berlin.*

Keys to genera and species are given. Several hundred species and forms are described and figured with numerous new ones.

Vaughan, Thomas Wayland.

A Note on the Names *Cyclosiphon* Ehrenberg, 1856, and *Lepidocyclina* Gümbel, 1868.

(Journ. Pal., vol. 3, no. 1, March, 1929, pp. 28-29.) Austin.

On account of the questionable standing of *Cyclosiphon*, *Lepidocyclina* should be retained.

Cushman, Joseph A.

A Fossil Member of the Family Pegididae.

(Journ. Washington Acad. Sci., vol. 19, no. 6, March 19, 1929, pp. 125-127, text figure.) Baltimore.

A new species of *Pegidia* is figured and described from the Miocene of Kostej.

Berry, Willard.

Two new species of "Orthophragmina" from Calita Sal, Peru.

(l. c., vol. 19, no. 7, April 4, 1929, pp. 142-145, text figs. 1-4.) Baltimore.

Sections and exteriors are figured, and the two species described in detail.

Cushman, Joseph A.

The genus *Trimosina* and its relationships to other genera of the Foraminifera.

(l. c., vol. 19, no. 8, April 19, 1929, pp. 155-159, 3 text figs.) Baltimore.

Two new species are described and figured, and the relationship of the genus discussed.

Cushman, Joseph A. and R. T. D. Wickenden.

Recent Foraminifera from off Juan Fernandez Islands.

(Proc. U. S. Nat. Mus., vol. 75, Art. 9, 1929, pp. 1-16, pls. 1-6.) Washington.

Collections from this region are described and figured with a few new forms.

Cushman, J. A. and Y. Ozawa.

Some Species of Fossil and Recent Polymorphinidae Found in Japan.

(Jap. Journ. Geol. Geog., vol. 6, 1929, pp. 63-78, pls. 13-16.) Tokyo.

A number of species from the younger Tertiary are described and figured, of which 7 are new.

Cushman, Joseph A. and Yoshiaki Ozawa.

A Revision of Polymorphinidae.

(Jap. Journ. Geol. Geog., vol. 6, 1929, pp. 79-83, text figs.
1, 2.) Tokyo.

The relationships of the genera and subgenera are discussed and illustrated.

J. A. C.

